(NASA-CR-135760) F-1 ENGINE SYSTEM Monthly Progress Letter, period ending 31 Jul. 1961 (Rocketdyne) 28 p

N73-74133

Unclas
00/99 19011

UNCLASSIFIED

NASA/NAA

August 24, 1961

TO UNCLASSIFIED CLASSIFICATION CHANGE
By authority of NASA Hq. (Code 242)-Maine
Changed by [illegible] Date 4/15/73

George C. Marshall Space Flight Center
Huntsville, Alabama

Attention: (1) S. F. Morea, Code M-S&M-PP
(2) W. Davis, Code M-P&C-DTR

Subject: Contract NASw-16 - Monthly Progress Letter on F-1 Engine System, Period Ending 31 July 1961

Gentlemen:

The original and eight copies of Rocketdyne letter, dated August 15, 1961, reference 61RC12149, with two (2) copies of Enclosure (1) and nine copies each of Enclosures (2), (3), (4), and (5) are forwarded herewith.

The following additional comments are presented for your information:

1. Thrust Chamber - Test Activity

In view of the persistent difficulties encountered at thrust chamber test stand 2A with operation of the LOX facility valve and LOX and fuel tank pressure regulators, it is recommended that MSFC send a valve specialist to Canoga Park to review the proposed modifications of these items.

2. Thrust Chamber Fabrication

The first 10:1 Inconel-X thrust chamber was furnace brazed August 8. The pressure bag operated satisfactorily during furnace brazing operation; however, six between tube leaks at the bifurcated splice area, and tube to tube leakage at the injector end ring was noted by post braze inspection. The chamber will be rebrazed in the furnace in the inverted position with NiOro braze used as the repair braze alloy.

3. Controls

Fire damage to one of the Jupiter ground LOX start systems noted by

CONFIDENTIAL

28p.

Rocketdyne is insufficient to preclude its use with the engine systems on Test Stand 1B at EAFB.

4. <u>Controls</u> (Cont'd.)

On Page 9, change "engine control valve" to read "Engine 4-way solenoid control valve". A complete engine harness built with metal enclosed armored cable will not be built for use on an R&D test engine until evaluation of the harness segments on engine 002 has been completed.

On Page 9, "Mark 10 Turbopump Retainer" should read "MK 10 Turbopump LOX bearing retainer".

Sincerely,

Frank P. Boffola

F. P. Boffola
F-1 Project Manager at Rocketdyne

Encs. (9)

Copies to: NASA Hdqtrs, Code LPL, A. O. Tischler, w/encs. (4)
NASA/EAFB, R. D. Groeneveld, w/encs. (1)
NASA/WOO, D. Mulholland, w/encs. (1)

61RC12149

15 August 1961

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama

Attention: S. F. Morea M-S&M-PP
Technical Information Contract NASw-16

Subject: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

Through: NASA F-1 Resident Project Manager at Rocketdyne
A Division of North American Aviation, Inc.

Enclosures:
(1) Two (2) copies of Rocketdyne Packing Sheet No. Z-61-25859 listing:
(2) Sixteen (16) copies of F-1 Weight Status
(3) Sixteen (16) copies of F-1 Engine Program Schedule
(4) Sixteen (16) copies of F-1 Engine Program Schedule (detailed June through September 1961)
(5) Sixteen (16) copies of F-1 Progress Status Chart

Gentlemen:

1. Thrust Chamber

Test Activity

Twelve thrust chamber test attempts were made and four achieved the intended duration. One test was terminated by combustion instability and seven were terminated by facility operational difficulties.

Test firing of the first single fuel manifold thrust chamber (10:1 nickel hand brazed) was limited to two tests of short durations (1.3 seconds each) because facility malfunctions caused high mixture ratio operation. The high mixture ratio (in excess of 5.0) on the second test resulted in a burned and split tube

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 2
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

1. Thrust Chamber (continued)

Test Activity (continued)

in the throat region. Although intended durations were not achieved, the start and thrust build-up characteristics of the single manifolded chamber were completely satisfactory. The tube damage has since been repaired and the chamber is being assembled into engine S/N 004.

Prior to testing of the single manifold chamber, a checkout of the facility was conducted using an extensively repaired triple manifold chamber assembled with flanged pipes in place of the fuel valves. The facility ball-type fuel valve was used for both start and shut-down in the same manner that would be used with the single manifold chamber. With this method of valving, the chamber jacket is only partially prefilled with water due to the thrust chamber attitude and there is an air space in the fuel line between the chamber and the water fill downstream of the facility fuel valve. The starts were satisfactory with no evidence of surges in the fuel system. One mainstage test was conducted with a previously repaired Inconel-X 3:1 chamber (S/N 002R) to evaluate tube repair methods. Pinhole leaks occurred in the repaired tube areas and an external crack of a manifold weld was noted. The operating level (P_c = 1091 psi) was inadvertently set too high for this test and resulted in overstressing the manifold which had been weakened during initial fabrication.

Four tests were made with Inconel-X thrust chamber S/N 007 to check out a standard baffle injector for engine use. Both injector and chamber operated satisfactorily for the accumulated duration of 33 seconds. This chamber has now accumulated 135 seconds of operation.

One unstable test was incurred during the initial evaluation of an unbaffled injector containing a closely spaced matched orifice pattern. The purpose of the test was to establish the stability characteristics and performance of the injector. As a result of the instability, one of the poppet type 180° fuel valves failed. All future thrust chamber testing will be conducted without the 180° fuel valves.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala Page 3
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Montnly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

1. Thrust Chamber (continued)

Thrust Chamber Fabrication

The first single manifold nickel hand brazed chamber was completed and fired. A 3:1 Inconel-X chamber (S/N 004) was furnace brazed using internal pressure bag tooling. Operation of the tooling was satisfactory as evidenced by good brazing of the tubes to shell and bands. Joints obtained at the injector end ring were not satisfactory, however, and a second furnace run is planned.

Preparations for furnace brazing the first 10:1 Inconel-X chamber are essentially complete. The chamber has been stacked and alloyed, as has a test bundle assembly that is intended to precede the complete chamber into the furnace. Pressure bag tooling has been installed in the test assembly and brazing will commence early in August.

The problem of obtaining leak tight joints at the Inconel injector end ring during a single braze cycle may be resolved on future chambers by nickel plating the drilled holes into which the tubes fit. Laboratory tests have indicated that braze wet-ability can be more positively obtained on the nickel plating than on the Inconel.

Braze improvement at the exit end ring is also expected by providing a slightly looser fit of the tubes into the drilled holes.

Injector Fabrication

Three injectors were completed this month of which two are of the baffle type. One injector (S/N 15-1) contains the standard thirteen compartments with three inch depth and has been check-fired for engine use. The other baffle injector (S/N 048) contains 25 compartments with three inch depth, and will be evaluated as part of the baffle optimization program.

The third completed injector (S/N 054) is unbaffled, of the matched 5U pattern and differs only in that the fuel ring grooves are more shallow than normal. This injector will be evaluated from a stability basis.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

FORM 81 L-2 REV. 3-61

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 4
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

I. Thrust Chamber (continued)

Injector Fabrication (continued)

Furnace brazing of the copper baffled injectors has been distinctly improving in quality of the joints due to design changes affecting the igniter system and baffle fits.

Nozzle Extension

Fabrication of the 150K size gas cooled nozzle extension is approximately 60 percent complete.

Design of the full scale extension is complete and will be released early next month.

The primary effort during the next report period will include brazing of the first 10:1 Inconel-X thrust chamber and continued evaluation of baffled injectors.

Thrust Chamber Test Summary is presented as Table I.

2. Turbopump

Five hot fire tests (Runs 029,030,031,032,033) were made on turbopump S/N R007R at the 1050K thrust level. LN_2 and RP-1 were used as pump fluids during one test, and LOX/RP-1 was used during the other four tests. The tests were conducted to verify turbopump performance and operation prior to delivery for installation in engine S/N 004.

Turbopump Test Summary is presented as Table II.

The fuel inlet seal leaked between 30 and 90 cc during tests. The primary LOX seal leaked during the last three tests. The seal was removed after test #030 and replaced with a reworked seal. As leakage was still present, this seal was removed after test #031 and replaced with a new seal using a modified secondary seal. Some GOX leakage was present at the LOX seal drain, however, since no LOX leakage was observed the turbopump was removed from the test stand and prepared for delivery to the engine. The total test time accumulated on this turbopump was 120 seconds.

[redacted]

TEST SUMMARY - JULY 1961

RS/EAFB Test Stand-2A

Test No.	Date	Objective	Duration	P_c Psia	C^*	M.R.	Remarks
049	7/3	Evaluation of tube repairs in 3:1 Inconel-X T.C. S/N 022R Injector S/N 024 (unbaffled)	12.6	1090	6200	2.51	1" external crack - manifold assembly. Pinhole leaks in throat at previous repairs. Exit manifold braze cracks.
050	7/10	Establish start sequence using facility MFV. T.C. S/N 002R (10:1 nickel) Injector S/N 024 (unbaffled)	0	-	-	-	Cut due to LOX inlet leak.
051	7/10	Same as test 050.	5.0	1060	6210	2.35	Injector and exit ring erosion. Throat tube splits and braze at previous tube repairs.
052	7/20	Single manifold 10:1 nickel T.C. checkout prior to engine build. Injector S/N 004 (baffled)	0	-	-	-	Observer cutoff due to fire in dome area. Igniter fuel line leakage.
053	7/21	Same as test 052.	1.30	-	-	.75	M.R. cutoff due to LOX tank pressure decay.
054	7/21	Same as test 052.	1.30	-	-	5.79	M.R. cutoff due to fuel tank pressure decay. T.C. tube split and overheating.
055	7/25	Evaluation of close spaced pattern S/N 046 (unbaffled) UCTC.	0	-	-	-	Cutoff due to failure of MLV to reach open.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

Table I
Page 1 of 2
61RC12149

CONFIDENTIAL

TEST SUMMARY - JULY 1961

RS/EAFB Test Stand-2A

Test No.	Date	Objective	Duration	P_c Psia	C*	M.R.	Remarks
056	7/26	Same as test 055.	0	-	-	-	RCC cutoff during transition. One fuel valve ruptured. Minor T.C. and injector erosion.
057	7/27	Check firing of baffled injector prior to engine build, T.C. S/N 007 3:1 Inconel-X	1.0	-	-	-	Cutoff due to fuel tank pressure decay.
058	7/27	Same as test 057.	1.5	-	-	-	MR cutoff - erroneous.
059	7/27	Same as test 057.	10.3	835	6210	2.40	Satisfactory test.
060	7/28	Same as test 057.	20.4	825	6190	2.25	Satisfactory test.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

- -

2. Turbopump (continued)

The first engine test during this report period was cut at 5.6 seconds by an observer. A review of data and inspection of hardware showed that a LOX suction line temperature bulb broke off and went through the LOX pump damaging the LOX inlet, inducer and impeller. Inspection of the parts of the temperature bulb indicated the failure was due to insufficient weld joint strength. The LOX inlet, inducer and impeller were reworked and reinstalled into the turbopump. Subsequently, four additional engine tests of 15, 20, 19.44 and 8 seconds, respectively, were conducted successfully. This turbopump has accumulated 74.9 seconds of testing on this engine.

Calibration Rig

Seven GN_2 spin tests with the fuel pump only were conducted during this report period. The LOX inducer and impeller had been removed and the LOX volute pressurized to approximately 147 psig with H_2O to add support to the LOX volute back plate. This type of support tends to minimize fuel volute back plate deformation and maintains a more constant axial shaft thrust level. The data from these tests is being evaluated.

The thrust, flow, head and HHP data derived from previous tests appears to be conforming to calculated design performance within acceptable limits. The torque meter data does not agreed with calculated performance criteria and is being studied to determine what correction factors must be used in reducing data and what design modifications will be required to obtain data with reduced scatter.

Most of the details and detail assemblies for the new calibration rig have been fabricated and assembly of the thrust meter is scheduled to start during the first week in August.

[redacted]

- -

2. <u>Turbopump</u> (continued)

<u>Design</u>

The drawing incorporating thick turbine wheels, double wear rings for the fuel volute and horizontal drain provisions has been released.

The MOD II design which includes thick fuel and LOX pump discharge flanges has been released.

<u>Components</u>

The first two sets of MOD-I LOX fuel pump volutes satisfactorily passed hydrostatic tests. The first set was proof tested to destruction. Failure occurred at pressure equal to 200 percent of the maximum operating level. The second set of volutes were successfully proof tested at 110 percent of maximum operating pressures. The LOX and fuel volute being tested together were first exposed to 110 percent pressure in the LOX volute with 0 pressure in the fuel volute. The fuel volute was then exposed to 110 percent maximum operating pressure while the LOX volute was held at 0 pressure. Subsequently, both volutes were simultaneously exposed to pressures equal to 150 percent LOX pump and 130 percent fuel pump maximum operating pressures.

The specification for the duplex thrust bearings has been released.

Two fuel inlet seals modified for higher hydraulic nose loading and increased spring loading were exposed to 21 tests, accumulating 4185 seconds. The dynamic leakage ranged between 0.5 cc/second at 30 psig fluid pressure to 1.2 cc/seconds at 150 psig fluid pressure. The carbon nose wear rate on one seal was approximately .0001 inch/1000 seconds.

Layouts for floating LOX impeller seals are in process.

The primary effort during the next report period will be to complete the assembly of the first 1500K turbopump and to continue testing to evaluate the turbine wheel vibration characteristics.

TURBOPUMP TEST SUMMARY

JULY 1961

S/N 007

Date Run	Duration (seconds)	Pump Fluids	App. Thrust Level	Oxidiser Pump Head (Ft.)	Oxidiser Pump Flow (GPM)	Fuel Pump Head (Ft.)	Fuel Pump Flow (GPM)	Speed RPM
7/12	30	LN_2/RP-1	1050K	2260	18,000	3040	15,500	4620
7/12	30	"#	"	2240	17,400	3090	14,700	4580
7/13	15	"	"	2240	17,600	3430	12,200	4630
7/15	15	"	"	2320	17,900	3550	11,800	4660
7/18	15	"	"	2250	18,300	3460	11,400	4620

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

[redacted]

- -

3. Gas Generator

Combustor

Component development testing continued with six tests. The first four tests of 10, 10, 100, and 100 seconds checked out a ball valve for engine backup support. This ball valve uses the first pressure balanced multiple convolution seals. The last two tests of this report period began a generator assembly checkout for engine S/N 004. The two tests were of 20 and 100 seconds durations with flow rates of 118 and 150 lb/seconds respectively.

Measurement of skin temperatures at various points on the generator assembly has begun. High response pressure recordings are being taken in the upstream end of the combustion chamber for hardware stability evaluations at wide range operation.

System

An injector was chedked out for turbopump support with two tests in the systems pit. These two tests of 30 and 100 seconds duration also calibrated adapters with orifices to replace the flow regulators on engine S/N 001. At 93 lb/seconds total flowrate and 1700°F the pressures required were 1420 psi fuel and 1320 psi LOX bootstrap pressures.

A four-way solenoid actuated hydraulic control valve is available for component evaluation. It will be installed and used to actuate the gas generator ball valve with simulated engine hydraulic pressures. A second injector will be check fired for turbopump support.

Design

Design effort is about 90 percent complete on the assembly layout for an injector design utilizing electron beam welding to replace all present braze and weld joints. This design allows almost complete machining prior to welding, which simplifies assembly machining and lessens the chance for machining chips in the injector manifolds after brazing. An improved weld technique will improve the present injector fabrication techniques.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

CONFIDENTIAL

FORM 81 L-2 REV. 3-61

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala.
Attn: S. F. Morea M-S&M-PP   61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

3. Gas Generator (continued)

The primary effort during the next report period will be continued evaluation of the gas generator system with orifices replacing the regulators.

4. Controls

Test data from the initial force balance tests of the main oxidizer valve have been reduced. The data, however, is unsatisfactory due to lack of good flow instrumentation. A test fixture has been redesigned to provide a mechanically adjusted valve position and make use of a load cell for measuring closing forces during the force balance test.

The assembly drawing of the fuel actuated main oxidizer valve for engines S/N 007 and S/N 008 is ready for release.

Die forging has been selected for the main oxidizer valve housing for engines S/N 009 and subs.

Two Jupiter ground LOX start systems have been received from NASA. One showed evidence of fire damage.

The first 90° main fuel valve of the engine S/N 004 configuration has been assembled and shipped to Santa Susana for CTL-3 testing. Actuation of the 90° valve appears to be slightly faster than the 180° valve for similar conditions.

Main fuel valve pilot valve tests are being conducted to study piston spring seat galling encountered during functional test.

The first new configuration phase II gas generator ball valve has successfully been utilized in three gas generator pit firings. The second and third new configuration phase II gas generator ball valves have been assembled and tested in the Engineering Laboratory and have been delivered to Santa Susana for testing. The fourth new configuration phase II valve is now being assembled in the Engineering Laboratory. Total number of phase II ball valves now in existence is five, which exceeds current gas generator assembly requirements.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 9
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

4. Controls (continued)

Engine Systems has requested that the H-1 piston-type ignition monitor valve be incorporated on engines S/N 001 through S/N 006. H-1 ignition monitor valve diaphragm burst tests are in work to provide design data for design of engine S/N 007 and subs diaphragm type ignition monitor valve. Layout of the ignition monitor valve for engines S/N 007 and subs has started.

Design parameters compatible with system requirements and component capabilities have been established for the igniter fuel shut-off valve. Cracking pressure will be 375 ± 30 psig, with 200 psig reseat pressure. Adjustment (probably shims) to eliminate spring variations will be required to hold this tolerance.

A control and test panel, ground relay box, and interconnecting ground cables have been shipped to Edwards to activate Test Stand-1B-1.

Effort is being directed towards fabricating an R&D Rocketdyne built metal enclosed armored harness for engine S/N 002. Upon completion the harness will be shipped to Edwards for installation on the engine. This harness will only include the wires going to and from the engine control valve.

The first Mark 10 Turbopump Retainer with hermetically sealed heaters has been built and tested in the Engineering Laboratory.

The linear analogue computer model of the gimbal system was combined with a limited non-linear model of the servo valve, and data is being obtained.

Gimbal system rod end bearing tests continue to produce satisfactory results. The bearing, treated with electro-film 77-S film lubricant, was readied for the 1000 cycle test at the maximum load of 150,000 pounds. The bearing thus far has been subjected to a total of 3,000 cycles of ±4° rotation with loads varying from 75,000 to 125,000 pounds.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

FORM 81 L-2 REV. 3-61

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 10
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

4. Controls (continued)

An examination of the hard anodized aluminum gimbal actuator sleeve bearing and the bronze bearing showed the aluminum bearing to have experienced very little damage. Except for some burnishing of the bearing surface in the region of load application the tests were satisfactory. The bronze bearing had suffered considerable wear. Tests have been started on another type of bronze bearing and a steel backed lead-indium bearing.

The gimbal system servo valve Equipment Specification has been revised to reflect changes broung about through design reviews attended by the vendors. Vickers has replied to the design review report and revised Equipment Specification indicating all required action has been complied with. They are presently cutting hardware on the valve.

The primary effort during the next report period will be testing of LOX valves and the new 90° fuel valves.

5. Engine System

Mainstage testing of the first engine, S/N 001, continued during this report period at Rocket Site/EAFB Test Stand-1A. Six successful mainstage tests were conducted at thrust levels of approximately 1000K with a maximum duration of 20 seconds. These tests increased confidence in attaining stable starting and steady state mainstage. Attemps were also made to decrease the starting sequence time.

Test Summary is presented as Table III.

One test, a scheduled 15 second mainstage test, was terminated prematurely by a chart observer after approximately 6 seconds of mainstage. The LOX pump inlet temperature bulb failed during mainstage causing the temperature indication to rise above the maximum allowable pre-start valve. Inspection of the temperature bulb indicated that approximately 3 inches at the tip broke off and entered the engine LOX system. The LOX pump was disassembled and a 1.5 inch long platium core of the temperature bulb was found. The inducer, impeller and pump inlet revealed spiral scoring and burned spots. These parts were refurbished and reinstalled in the engine.

[redacted]

- -

5. Engine System (continued)

While the turbopump was disassembled, the turbine wheels were removed and inspected for cracks by use of a dye penetrant. No cracks were found in the turbine wheels, however, several cracks were noted in the segmented second stage nozzle block. As a precautionary measure, all segments of the second stage nozzle block were replaced. The cause of this cracking is presently under investigation. Approximately 32 seconds of mainstage time had been accumulated on engine S/N 001 at the time of inspection.

The flexible high pressure hydraulic control line harness assembly to the poppet type main fuel valves and gas generator valve were replaced with stainless steel tubing when hydrostat tests on similar flex lines for engine S/N 002 indicated the lines were failing at approximately 2400 psig, which is just above normal operating pressure. This same change was incorporated in engine S/N 002.

Efforts are being expended in an attempt to speed up the starting sequence. To achieve this objective, bleeds were installed in the LOX high pressure ducting and the gas generator LOX bootstrap line, the main LOX valves and gas generator valve opening times were decreased and the main fuel valves pilot valve cracking pressure was lowered. Test data to date does not reflect a significant change in starting time, however, analysis is still continuing in this area.

Vibrations during steady state mainstage operation are being experienced in the LOX pump inlet suction ducting. Analysis of this condition with respect to suction duct strength is under investigation.

The 5:1 watercooled thrust chamber extension skirt was damaged beyond repair on the 20 second test. A skirt was not installed on subsequent tests. This in turn required a modification to the turbine exhaust duct and the addition of a water manifold between the turbine exhaust duct and the thrust chamber exit. Removal of the extension skirt resulted in a slight decrease in performance.

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 12
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

5. Engine System (continued)

Thrust chamber firex is being directed on the engine during the tests as a safe guard against excessive heat radiation. The duration of each test will be increased if heat radiation does not present a problem with the 3:1 configuration.

Orifice sizes chosen to replace the fuel and LOX flow regulators on engine S/N 001 were tested in the gas generator test facility. These orifices are presently being installed on the engine.

The interim ignition monitor valve, which has been installed on engine S/N 001 for monitoring actuation time only, is also being installed in the control system. The orificed gas generator is expected to provide a slower power build-up rate allowing safe incorporation of the ignition monitor valve. The design of the ignition monitor valve has been finalized and will be employed on engines S/N 007 and subs.

Engine S/N 002 was shipped to RS/EAFB after successfully completing leak and functional checkouts. Installation of the engine on Test Stand-1B-1 was started following main tank and flowmeter calibrations. The first test on this engine is scheduled for August. The initial test program will be similar to that of engine S/N 001. (See Note "A" Enclosure #4).

Assembly of engine S/N 004 has been started. This engine will have a 10:1 single manifold thrust chamber with two 90° poppet fuel valves.

As a result of a meeting with NASA at Marshall Space Flight Center it was determined that the proposed vehicle tank and propellant duct configuration will provide adequate conditions for a tank heat start. It was pointed out by NASA personnel that by lowering the turbopump NPSH requirements a significant total vehicle weight saving could be realized with respect to tank pressurization hardware and fluids.

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 13
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

5. Engine System (continued)

Several mutually agreeable compromises were formulated at this meeting with respect to the Model Specification. The capabilities of increasing the engine gimbal envelope to 6° was discussed in detail. The first engine capable of this increased gimbal angle is engine S/N 014 according to present schedule.

The primary effort during the next report period will be hot firing on Test Stand-1B-1 and completion of the first engine with a single manifold thrust chamber.

6. Facilities

Thrust Chamber Stand-2A

Miscellaneous modifications and additions are presently being accomplished. Included are spare valves, anchors for GN_2 and LOX lines.

Engine Test Stand-1A

As a result of erosion caused by engine test firings, the completed designs for the flame deflector, road and erosion control require minor modification. The changes will be completed and bids solicited during the next report period.

Miscellaneous other projects are presently being accomplished. These consist of weather shielding, firex and instrumentation improvements, and a craneway catwalk.

Engine Test Stand-1B

Construction of the test stand was completed 15 July 1961.

LOX Storage and Transfer System

Prefabrication of the vessels prior to installation is 45 percent complete.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

[redacted]

TEST SUMMARY

RS/EAFB Test Stand-1A

JULY 1961

Test No.	Date	Objective	Mainstage Duration	Thrust Level	Remarks
421-010A	7/3	10 second mainstage test	10.0 sec.	980K	Successful 9.95 second mainstage test.
421-011A	7/6	15 second mainstage test	6.0 sec.	1003K	Observer cutoff when LOX pump inlet temp.bulb failed.
421-012A	7/17	15 second mainstage test	15.6 sec.	1016K	Successful test.
421-013A	7/20	20 second mainstage test. Speed up start sequence.	19.4 sec.	1006K	Successful 19.4 test. No appreciable speed-up of start sequence.
421-014A	7/26	8 second mainstage test. 5:1 extension skirt deleted. Speed-up start sequence.	8.4 sec.	960K	Successful test with 3:1 thrust chamber. No appreciable speed-up of start sequence. No heat radiation problem with 5:1 skirt removed.
421-015A	7/28	10 second mainstage test. 5:1 extension skirt deleted.	9.9 sec.	962K	Successful test with 3:1 thrust chamber.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

CONFIDENTIAL

To: Geo.C.Marshall Space Flight Center,NASA,Huntsville,Ala. Page 14
Attn: S. F. Morea M-S&M-PP 61RC12149
From: Rocketdyne, Canoga Park, California
Subj: Monthly Progress Letter on F-1 Engine System
Period ending 31 July 1961

- -

6. Facilities (continued)

LOX Storage and Transfer System (continued)

The LOX transfer line supports have been completed to the LOX vessels. Work is progressing on the installation of the GN_2 supply line, sewer line and railroad. This portion of the construction is 30 percent complete.

Completion of both contracts is scheduled for 15 September 1961.

Braze Furnace System

The overall project is 98 percent complete. The braze furnace contractor completed relining the furnace walls and ceiling with thermal shock-resistant fiberfrax blanket material. The base was completely reworked, however, some failure in the hearth beams has been experienced due to thermal shock. Rocketdyne has had use of the furnace for braze operations during the continued activity by the furnace contractor.

FY-1961 Appendix "A", Supplement "A"

Consists of miscellaneous facilities at Canoga and Rocket Site, Edwards Air Force Base. The Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, is in the process of providing contractual coverage on Facilities Contract AF33(600)-26940.

Very truly yours,

NORTH AMERICAN AVIATION, INC.
Rocketdyne Division

DEAldrich
D. E. Aldrich
Program Engineer
F-1 Engine System

DEA:DJS:rs

cc: W/encl: Commander
AFFTC, Research & Development Command
Edwards Air Force Base, California
Attn: FTRDL

cc: W/encl: AFPR, Canoga

MODEL F-1
CONTRACT NAS W-16
ISSUE CER-1111-4193
DATE 1 July 1961
ENCLOSURE 1
PAGE 1 of 3
REPORT NO.

			DES. GRP.	SPEC. WEIGHT PER R-1420s DATED 8 JAN 59	CON-TRACTOR CHANGES	CURRENT STATUS	LAST STATUS CER-1111-4189 DATED 1 JUN 61	CHANGES LAST TO CURRENT STATUS	BASIS FOR CURRENT DATA % EST.	% CALC.	% ACT.	NOTES
		1		2	3	4	5	6	7	8	9	10
1+4+5		Propulsion Sys. at Burnout		(16,516)	(+4,909)	(21,425)	(21,150)	(+ 275)	(23)	(52)	(25)	
2+4		Propulsion Sys. - Dry	158	(12,405)	(+5,015)	(17,420)	(17,145)	(+ 275)	(25)	(44)	(31)	
2+3	1	Rocket Engine at Burnout		(14,438)	(+2,549)	(16,987)	(16,712)	(+ 275)	(24)	(52)	(24)	
	2	Rocket Engine - Dry	158	(11,590)	(+3,518)	(15,108)	(14,833)	(+ 275)	(25)	(48)	(27)	
		Thrust Chamber	120	6,031	+1,053	7,084	6,810	+ 274	20	60	20	1
		Gimbal Bearing	121	375	+ 36	411	411	0	0	3	97	
		Turbopump Assembly	123	2,450	+ 173	2,623	2,603	+ 20	13	35	52	2
		Turbopump Mount	120	405	- 141	264	264	0	0	75	25	
		Oxidizer System	127	460	+ 353	813	813	0	0	68	32	
		Fuel System	127	618	+ 66	684	684	0	15	39	46	
		Electrical System	128	18	- 7	11	11	0	55	0	45	
		Lubrication System	158	73	- 66	7	7	0	76	21	3	
		Gas Generating System	121	312	+ 18	330	338	- 8	7	31	62	3
		Exhaust System	121	422	+ 529	951	951	0	11	86	3	
**		Vector Control System (Hydraulic)	158	387	+1,309	1,696	1,696	0	100	0	0	
		Ignition System	158	39	+ 10	49	49	0	43	20	37	
		Control System (Hydraulic)	158	0	+ 185	185	196	- 11	0	58	42	4
	3	Engine Fluids at Burnout		(2,848)	(- 969)	(1,879)	(1,879)	(0)	(17)	(83)	(0)	
	4	Accessories		(815)	(+1,497)	(2,312)	(2,312)	(0)	(30)	(17)	(53)	
		Heat Exchanger	121	248	+ 387	635	635	0	100	0	0	
*		Suction Lines	121	567	+1,045	1,612	1,612	0	0	25	75	
		Pressurization Suction Ducts	121	0	+ 65	65	65	0	100	0	0	
	5	Acc. Fluids at Burnout		(1,263)	(+ 863)	(2,126)	(2,126)	(0)	(4)	(96)	(0)	

*Weights, Col. 4 and 5, reflect suction line lengths twice those quoted in Spec. R-1420S.
**Weights, Col. 4 and 5, reflect prototype test hardware, flight design concept information not available.

WEIGHT STATUS REPORT — LIQUID ROCKET PROPULSION SYSTEM

CHANGES SINCE LAST REPORT

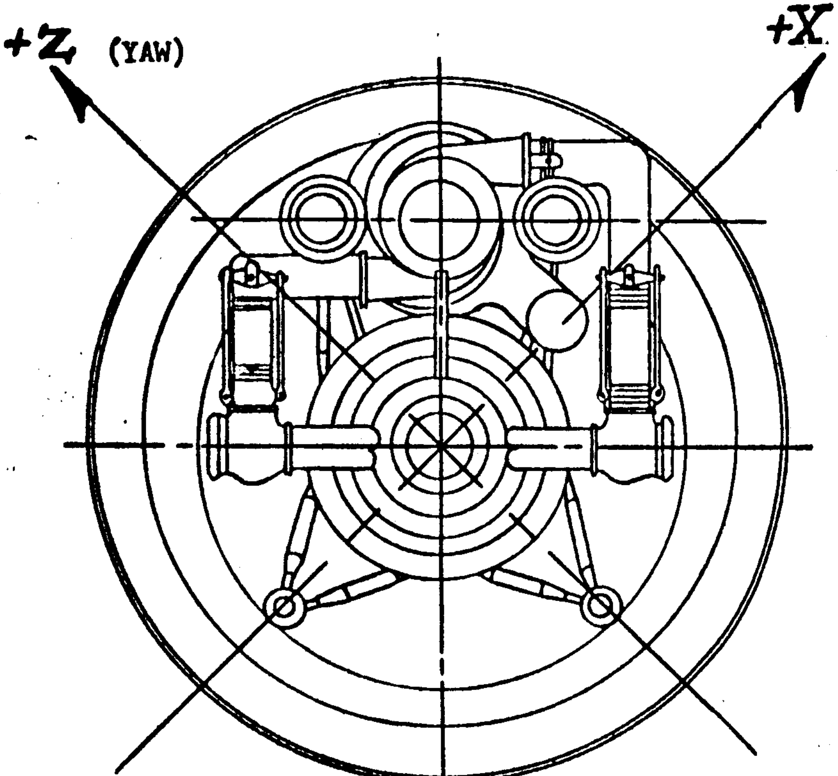
MODEL F-1 CONTRACT NAS W-16 ISSUE CER-1111-4193 DATE 1 July 1961 ENCLOSURE 1 PAGE 2 OF 3	G. F. E. WEIGHT CHANGE	CONTRACTOR WEIGHT CHANGE	EXPLANATION	NOTES
1	2	3	4	5
Propulsion System at Burnout		(+ 275)		
Thrust Chamber		+ 274	Combustion zone jacket wall increased in order to maintain material strength properties after furnace braze processing, (+ 242 lbs.); mount pad redesigned to accommodate additional pump strut (+ 32 lbs.).	1
Turbopump Assembly		+ 20	Redesign of ring spacer in turbine inlet manifold to accommodate seal (+ 20 lbs.).	2
Gas Generator System		- 8	Lightweight fuel regulator purchased from new vendor source, (- 8 lbs.).	3
Control System (Hydraulic)		- 11	Deleted fiberglass shielding over line assemblies not now required (- 11 lbs.).	4

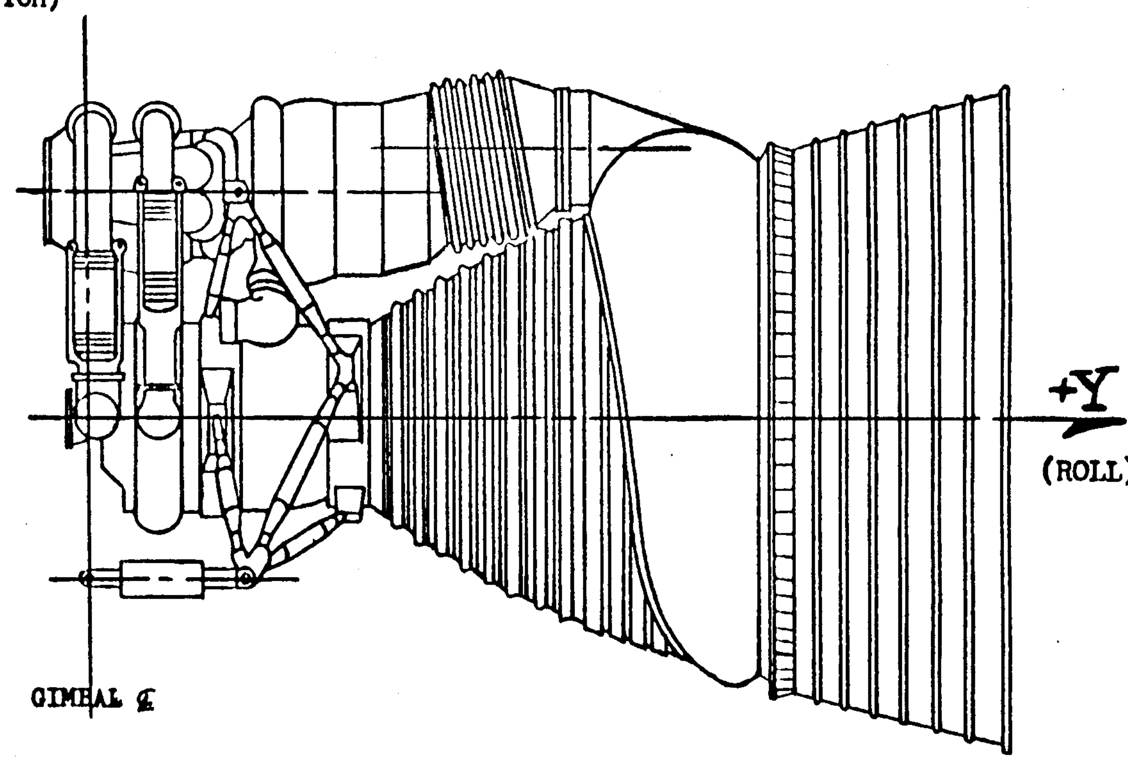
GIMBALLED MASS (~~DRY~~, WET, cross out one)		SPECIFIED	CURRENT
Weight	(lbs.)	15,265 pounds	20,134 pounds
Center of Gravity	(in. from gimbal axis)	58.6 inches	39.0 inches
Moment of Inertia	(Slug Ft.2)	28,472 slug ft^2	MAX I_z ' 27,303 slug ft^2 MIN I_x ' 23,951 slug ft^2

CENTER of GRAVITY and INERTIA DATA

MODEL F-1
CONTRACT NAS W-16
ISSUE CER-1111-4193

DATE 1 July 1961
ENCLOSURE 1
PAGE 3 of 3



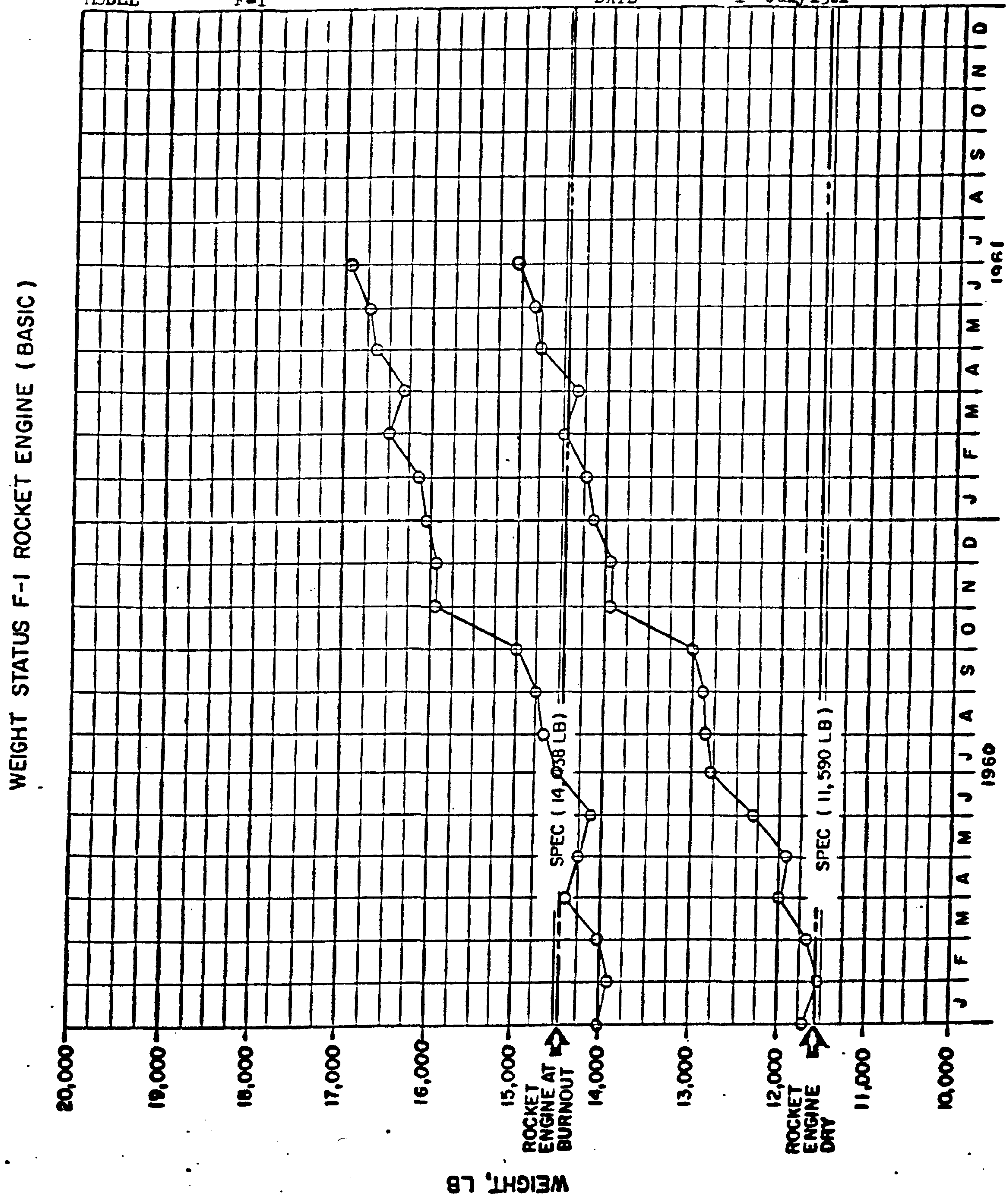


NOTE: Items (1) thru (4) represent the moment of inertia about specified C.G.'s. Item (5) presents the nominal gimballed mass moment of inertia about the gimbal axes.

DESCRIPTION	WEIGHT (lbs)	CENTER OF GRAVITY (inches)			INERTIA (slug-ft^2)		
		Y-arm	X-arm	Z-arm	ROLL	PITCH	YAW
(1) Propulsion System (Dry)	17,420	40.8	10.8	10.2	6,758	16,896	16,999
(2) Propulsion System (Wet)	21,800	31.1	13.7	13.0	8,155	22,797	22,946
(3) Rocket Eng. Dry (Incl.Ht.Exch.)	15,743	51.0	8.3	7.5	6,130	12,518	12,638
(4) Rocket Eng. Wet (Incl.Ht.Exch.)	18,083	49.2	9.3	8.4	6,950	13,894	14,077
(5) Gimballed Mass (Wet)	20,134	39.0	12.7	12.0	8,934	25,510	25,744

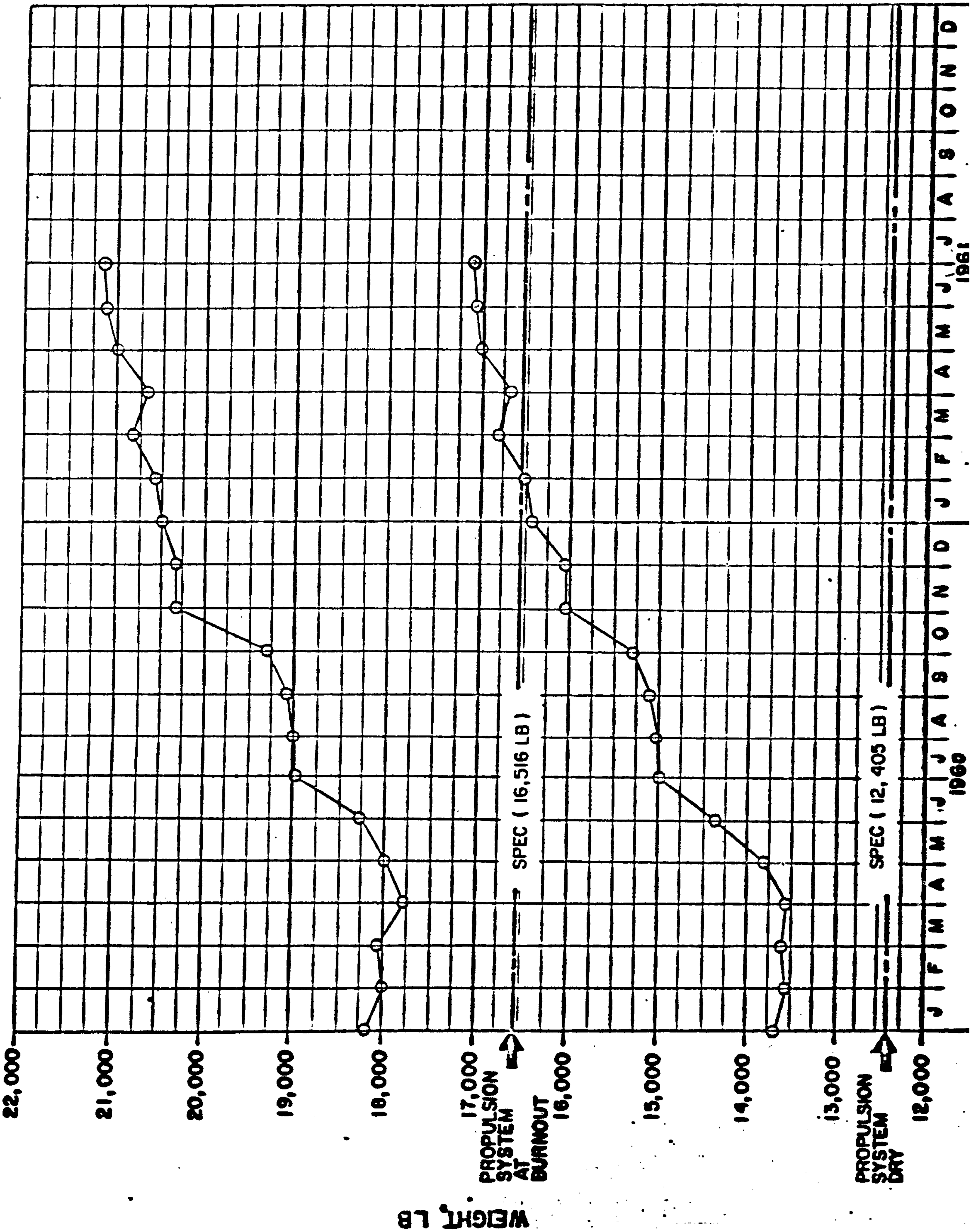
PREPARED BY D. A. Jelinek
REPORT NO.: CER-1111-4193
MODEL F-1

DATE 1 July 1961

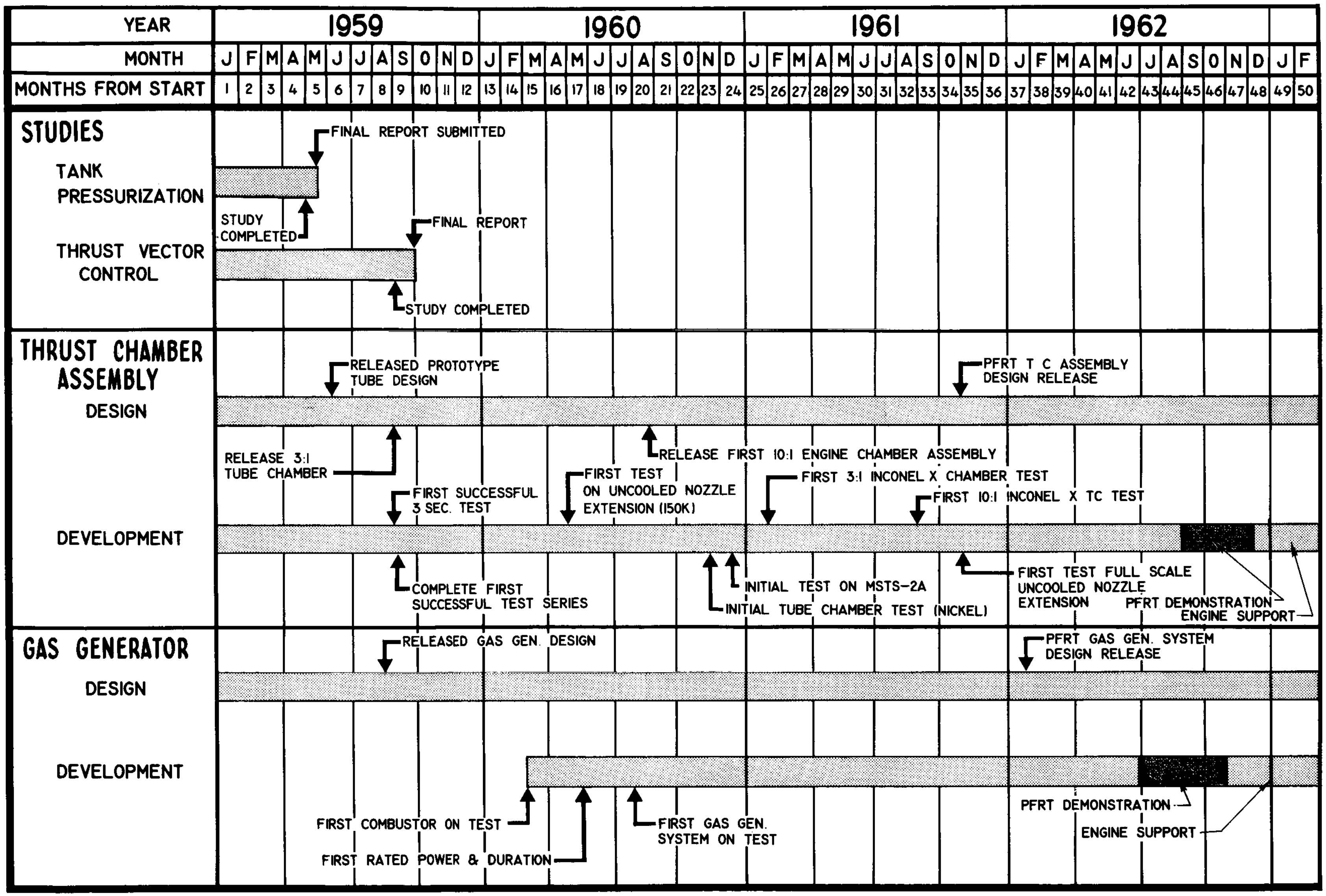


PREPARED BY	D. A. Jelinek	ENCLOSURE	2
REPORT NO.:	CER-1111-4193	PAGE	2 of 2
MODEL	F-1	DATE	1 July 1961

WEIGHT STATUS F-1 PROPULSION SYSTEM (ROCKET ENGINE PLUS ACCESSORIES)



F-1 ENGINE PROGRAM SCHEDULE



3-61-336-153 (PG 1 OF 2)

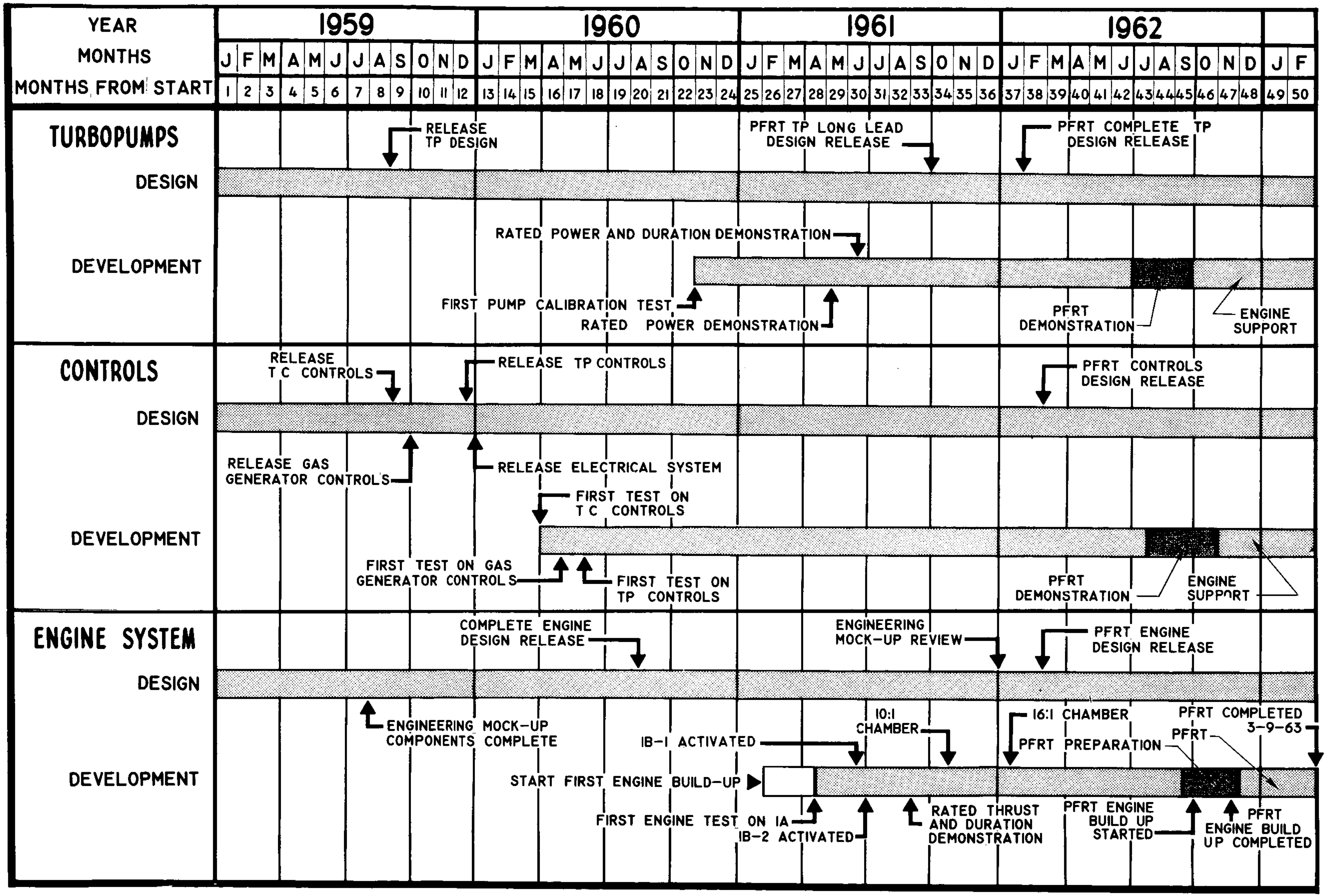
ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.

EXCLUDED FROM AUTOMATIC
REGRADING: DOD DIR 5200.10
DOES NOT APPLY

CONFIDENTIAL

EXCLUDED FROM AUTOMATIC
REGRADING; DOD DIR 5200.10
DOES NOT APPLY

F-1 ENGINE PROGRAM SCHEDULE (CONT'D)



3-61-336-153 (PG 2 OF 2)

[redacted]

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.

~~CONFIDENTIAL~~

F-1 ENGINE PROGRAM SCHEDULE

	1961 JUNE	JULY	AUGUST	SEPTEMBER
THRUST CHAMBER ASSEMBLY				
DESIGN			Release Full-scale Uncooled Extension	
* FABRICATION	(4)	(3)	(3) Furnace Brazed 10:1 Inc-X T.C.	(3)
TEST	T.C. Single Manf. Test		150K Gas Cooled Extension Test	1st Test 10:1 Inc-X T.C.
NO. of TESTS	15	15	15	15
GAS GENERATOR				
DESIGN				
* FABRICATION	(2)	(2)	(2) Compl. Low ΔP Inj.	(2)
TEST	Checkout #3 Eng. GG	Checkout #4 Eng. GG; Begin Range Capability Study	Checkout #5 Eng. GG	Checkout #7 Eng. GG; Complete Range Capability Study
NO. of TESTS	15	15	15	15

* NOTE: Number of Injectors Completed Each Month are Shown in Circles

EXCLUDED FROM AUTOMATIC REGRADING: DOD DIR 5200.10 DOES NOT APPLY

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

F-1 ENGINE PROGRAM SCHEDULE

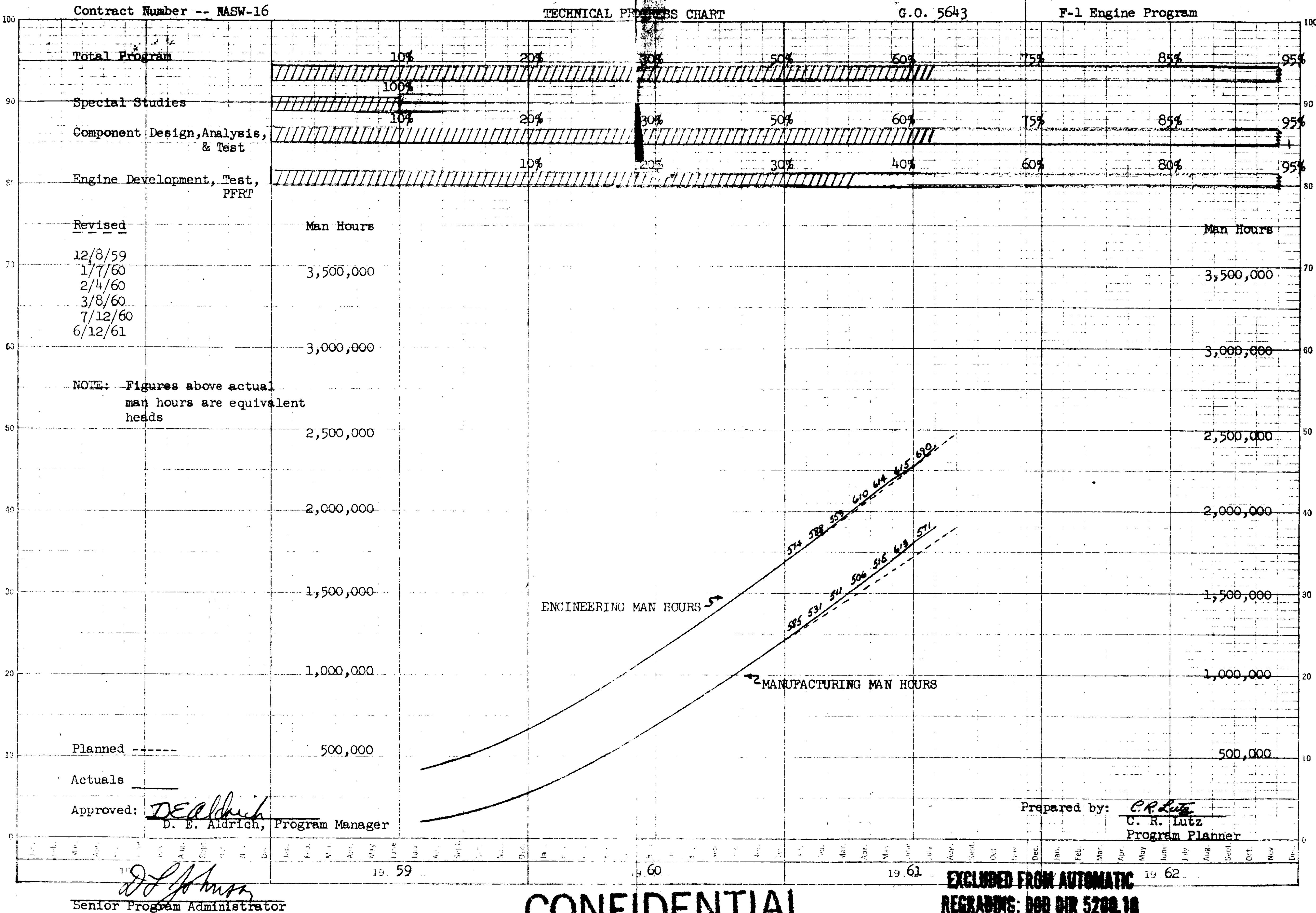
	1961 JUNE	JULY	AUGUST	SEPTEMBER
TURBOPUMP				
DESIGN				
* FABRICATION	(2)	(1)	(2) Del. 1500K T.P.	(2)
TEST		Activation Bravo 2C	Comp.Cal.1500K	Compl.Calib.of #003
NO. of TESTS	15	20	20	1st Test New Calib Rig 20
CONTROLS				
DESIGN		Rel.Details for MLV	(Fuel Act.)	
FABRICATION			Design Rel.#009 Ball	Valve
TEST		Initiate MFV Tests for Eng.004	Compl. 90° MFV Tests	
			Start GG Ball Valve Tests	
ENGINE SYSTEM				
DESIGN	Compl.Des.Rel.#6 Eng.			
FABRICATION	Start Assmy. #4 Eng.	Comp.Eng. #002	Comp. Eng. #004	
TEST	1500K Firing	#002 Eng.Instl. 1-B	Start Assmy. 1500K Engine #005	#005 Eng.Instl. 1-E
		1st #002 Eng.Test	A	
NO. of TESTS	11	12	12	12

* NOTE: Number of Units Completed Each Month are Shown in Circles

EXCLUDED FROM AUTOMATIC REGRADING: DOD DIR 5200.10 DOES NOT APPLY

~~CONFIDENTIAL~~

CONFIDENTIAL



CONFIDENTIAL

EXCLUDED FROM AUTOMATIC REGRADING; DOD DIR 5200.10 DOES NOT APPLY